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Selection of Variables in Clustering and Pattern Recognition

FINAL SCIENTIFIC REPORT

January 1, 1972 through December 31, 1976

Research Grant AFOSR 72-2259

prepared by

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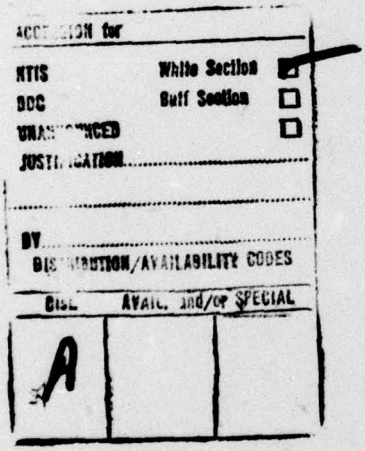

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1. Outline of Our Activities During 1972-1976

Our activities under the Research Grant AFOSR 72-2259 from January 1972 through December 1976 continued and developed our research project under the Research Grant AFOSR 68-1466, and produced 31 published papers and 2 accepted papers during this period. These publications are listed at the end of this report, and the major results of our research work during this period are all described in these papers.

We shall, however, sketch in the following our research activities subdividing them into seven sub-areas:

(1) Pattern Recognition: In this sub-area we have achieved three objectives. (1a) Improvement of the so-called perceptron method. The customary method leaves too much freedom for the allowable solutions which are often located in disproportionate positions. Our improved method permits us to obtain a solution which has a well-balanced location. The result is published in Paper 7. (1b) All the known pattern recognition methods assume that a class can be represented by an n-dimensional volume in the n-dimensional representation space. We introduced a revolutionary idea that a class can be represented by an m-dimensional subspace in the n-dimensional representation space, where $m << n$. The final version of this new method is published in Papers 12 and 32. (1c) Using the structural method of pattern recognition, we introduced an extremely versatile language called Chemical Structure Language. We can express not only all the chemical structure formulae, but also extremely intriguing graphs. Papers 1 and 29.

(2) Clusterings. We introduced, for the first time in the history of clustering algorithms, a unified view covering practically all the known algorithms. See Paper 5. Usual algorithms require an exhorbitant amount of

computer time and yet do not produce the true optimal solution. We introduced an entirely new method, which not only economizes the computer time, but also yields a unique optimal solution. Papers 17 and 30.

(3) Optical Method. We obtained many interesting results inserting various filters at the focal plan (where the Fourier transform is produced) of a converging lens, in front of which a picture is placed. The contour detection, simulation of the von Békésy function, texture analysis have been done. The results have not yet been published. But, in the future, they will be incorporated in published papers, and acknowledgement of AF grant will be made.

(4) Learning Theory. We introduced and defended the ideas of propensity automata as the model of learning process. This idea was motivated by two major reasons. For one thing, the existing learning models in terms of finite deterministic automata, stochastic automata and fuzzy automata are found all inappropriate. Second, the inverse H-Theorem must be satisfied. Papers 22 and 31.

(5) Artificial Intelligence. The main effort here aimed at clarification of the difference between the artificial intelligence and the natural intelligence. Paper 19 was devoted to criticize Dreyfus' book called Critique of Artificial Reason. A general discussion of the problem of artificial intelligence was entitled "Can the Cognitive Process be Totally Mechanized?" Paper 26. My positive assertion in this area is that the natural intelligence is carried out by the help of what I call "paradigmatic symbols" whereas the artificial intelligence is carried out with the help of "abstract symbols." Paper 77.

(6) Philosophy of Science. I felt it is important for the healthy

development of philosophy of science to destroy the now popular Kuhnian theory of scientific revolutions. My theory was described in Paper 24.

(7) Cybernetical Concept of Time. Norbert Wiener started his famous book "Cybernetics," with a chapter called "Newtonian and Bergsonian Concepts of Time." Nobody, however, pursued this very suggestive idea. My idea was from the beginning very close to N. Wiener's concept of time. I published several papers along the line of cybernetical concept of time. Papers 2, 3, 16, 18, 20, 23.

2. Papers Published with Partial Support by AF Grant from January 1972 to December 1976

1. S. Watanabe, "Ungrammatical Grammar in Pattern Recognition," *Pattern Recognition*, Vol. 3, No. 4, Pergamon Press, 1971, pp. 385-408.
2. S. Watanabe, "Creative Time," *The Study of Time*, (Fraser, Haber, Müller; eds.), Springer-Verlag, 1972, pp. 159-189.
3. S. Watanabe, "La Futurologie et le Concept du Temps, " Archives de L'Institut International des Sciences Théoriques, No. 17, *La Méthode Prospective*, Colloque de L' Académie Internationale de Philosophie des Sciences, Belgium, September 1968, Office International de Librairie, Bruxelles, 1972, pp. 35-40.
4. S. Watanabe, "Les Éléments Humains Arationnels Dans la Connaissance Scientifique," Archieves de L'Institut International des Sciences Théoriques No. 18, *De La Méthode*, Colloque de L'Académie Internationale de Philosophie des Sciences, Lausanne, September 1969, Office International de Librairie, Bruxelles, 1972, pp. 71-84.
5. S. Watanabe, "A Unified View of Clustering Algorithms," *Information Processing 71*, Proceedings of the IFIP Congress 1971, Ljubljana, Yugoslavia, North-Holland Publishing Company, Amsterdam, 1972, pp. 149-154.
6. B. Reiter and S. Watanabe, "Orthogonal Subspaces for Multi-Class Pattern Recognition," *Proceedings of the Fifth Hawaii International Conference on System Sciences 1972*, (Art Lew, ed.), Western Periodicals Company, 1972, pp. 398-400.
7. T. Kaminuma and S. Watanabe, "Fast-Converging Adaptive Algorithms for Well-Balanced Separating Linear Classifiers," *Pattern Recognition*, Vol. 4, No. 3, Pergamon Press, 1972, pp. 289-305.

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9. S. Watanabe, "Information," *Scientific Thought*, Mouton/Unesco, The Hague, 1972, pp. 129-144.

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11. S. Watanabe, "Paradigmatic Symbol - A comparative Study of Human and Artificial Intelligence," *Proceedings of the XXth International Congress of Psychology*, August 1972, Tokyo: Science Council of Japan, 1974, p. 236; also in *IEEE Transactions on Systems, Man, and Cybernetics*, Vol. SMC-4, No. 1, January 1974, pp. 100-103.

12. S. Watanabe and N. Pakvasa, "Subspace Method in Pattern Recognition," *Proceedings of the First International Joint Conference on Pattern Recognition*, November 1973, Washington, D.C. Northridge, California: IEEE Computer Society Publications Office, 1973, pp. 25-32.

13. S. Watanabe, "A-Rational Elements in the Progress of Science," *Proceedings of XIIIth International Congress of the History of Science*, Moscow, 1971, Section I, Moscow: Editions "Naouka", 1974, pp. 25-30.

14. S. Watanabe, "Tippie Top and Life," (in Japanese), *Shizen*, Tokyo: Chuo-Koron Publishing Company, May 1974.

15. S. Watanabe, "Report on Workshop on Possibilities and Limitations of Artificial Intelligence," and "Paradigmatic Symbol," in *IEEE Transactions on Systems, Man, and Cybernetics*, Vol. SMC-4, No. 1, January 1974, p. 88 and pp. 100-103.

16. S. Watanabe, "Time and Freedom," (in Japanese) in *Shiso*, Tokyo: Iwanami Shoten Publishers, August 1974, pp. 1-12.

17. S. Watanabe and E. Harada, "A Dynamical Model of Clustering," in the *Proceedings of the Second International Joint Conference on Pattern Recognition*, August 1974, Copenhagen: fototryk, 1974, pp. 413-415.

18. S. Watanabe, "Living with Entropy," (in Japanese), *Shizen*, Tokyo: Chuo-koron Publishing Company, February 1975, pp. 88-105.

19. S. Watanabe, "Some Thoughts on Dreyfus' *Critique of Artificial Reason*," *IEEE Transactions on Systems, Man, and Cybernetics*, Vol. SMC-5, No. 1, January 1975, pp. 141-145.

20. S. Watanabe, "Norbert Wiener and Cybernetical Concept of Time," *IEEE Transactions on Systems, Man, and Cybernetics*, 25th Anniversary Symposium of Wiener's Cybernetics, Vol. SMC-5, No. 3, May 1975, pp. 372-375.

21. S. Watanabe, "Complexity and Entropy," *The Proceedings of 1975 International Conference on Cybernetics and Society, San Francisco, Sept. 1975*, p. 407.

22. S. Watanabe, "Creative Learning and Propensity Automaton," *IEEE Transactions on Systems, Man, and Cybernetics*, Vol. SMC-5, No. 6, (Nov. 1975), p. 603

23. S. Watanabe, "Causality and Time," *The Study of Time*, Vol. 2, (Fraser and Müller, eds.), Heidelberg: Springer-Verlag, (1975), p. 267

24. S. Watanabe, "Needed: A Historico-Dynamical View of Theory Change," *Synthese, 32*, Dordrecht-Holland: D. Reidel Publishing Co., (1975), p. 113

25. S. Watanabe, "Logic of the Empirical World, With Reference to the Identity Theory and Reductionism," *Philosophical Aspects of the Mind-Body Problem*, (C.Y. Cheng, ed.), Proceedings of the Conference on the Philosophy of Mind and Psychology, University of Hawaii, March 1968. Honolulu: The University Press of Hawaii, (1975), p. 162; also in *Annals of the Japanese Association for Philosophy of Science*, Vol. 4(4), 1974

26. S. Watanabe, "Can the Cognitive Process be Totally Mechanized," *Philosophical Aspects of the Mind-Body Problem,* (C.Y. Cheng, ed.), Proceedings of the Conference on the Philosophy of Mind and Psychology, University of Hawaii, March 1968. Honolulu: The University Press of Hawaii, (1975), p. 182

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29. S. Watanabe, "Chemical Structure Language (CSL) and its Applications," *Proceedings of the Third International Joint Conference on Pattern Recognition,* Nov. 1976, San Diego, p. 602.

30. S. Watanabe, "Further Report on Coalescence Model of Clustering," *Proceedings of the Third International Joint Conference on Pattern Recognition,* Nov. 1976, San Diego, p. 176

31. S. Watanabe, "Propensity Automaton as a Model of Learning," *Proceedings of the International Conference on Cybernetics and Society, Washington, 1976,* p. 592.

32. S. Watanabe, "Moss - A Subspace Representation of Classes in Pattern Recognition," to appear in the *Transactions of the Seventh Prague Conference on Information Theory, Statistical Decision Functions, and Random Processes,* 1974, Prague: Publishing House of the Czechoslovak Academy of Sciences.

33. S. Watanabe, "La sémantique évolutionnelle," to appear in the *Proceedings of the 1974 Seminar on Semantics*, L'Académie Internationale de Philosophie des Sciences.

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Activities under the Grant continued and developed the research project under Grant 68-1466, and produced 31 published papers and two accepted papers during this period. These publications are listed at the end of the report, and major results of the research work during this period are all described in the papers.

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